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PATENT ABSTRACTS OF JAPAN

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(54) EXPOSURE DEVICE

(57)Abstract:
PURPOSE: To make it possible to perform alignment with higher accuracy by installing an automatic focussing device for alignment independently of an automatic focussing device for exposure.
CONSTITUTION: 'An electric signal related with an optical position of an exposed body is measured based on alignment mark optical information on the exposed body by way of a alignment detection optical system' An electric signal of each optical position at each point on the exposed body is imitated as a function dependent on the optical position. An optimum optical position is looked for at each point on the exposed body based on the functional features available from during the imitation. The optical position at each point thus obtained is subjected to statistical processing as information at each point on the exposed body. The optical position of the exposed body thus obtained is stored as the optical position optimum to alignment. A means to drive the exposed body to the optimum optical position is installed separately from an exposure focussing means or simultaneously. This construction makes it possible to improve the alignment accuracy.

LEGAL STATUS

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[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

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(57) [Claim(s)]
[Claim 1] It is the aligner characterized by for the automatic-focusing doubling equipment for exposure to form independently the automatic-focusing doubling equipment for alignment which detects a focal location based on the picture signal of the mark for [which is obtained by the optical system and the image sensor for alignment] alignment in the aligner which performs alignment detection with the exposed body, equipment or the exposed body, and the original edition using the optical information which passed through alignment detection optical system.
[Claim 2] The automatic-focusing doubling equipment for said alignment is an aligner according to claim 1 which is what measures the focal location in several shots of said exposed inside of the body, and detects the optical location of the optimal exposed body for alignment by statistics processing.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[Industrial Application]
This invention relates to the aligner with which the optimal optical location of the alignment mark at the time of detecting the relative-position relation between the original editions, such as the exposed bodies, such as a wafer, equipment, or a reticle, and the exposed body especially was doubled automatically about the aligner used for printing, such as a semi-conductor pattern.
[Description of the Prior Art]
In recent years, in a projection aligner, the alignment approach that precision is high, and the focusing approach that precision is high have been needed by the demand of detailed-izing of patterns, such as a semiconductor device, an LSI component, and a VLSI component, and high integration.
ultraviolet radiation applies to the grid mark on a reticle , and the optical lens for exposure passes about automatic-focusing doubling in a contraction projection aligner — after reflect in the datum plane locate in the same optical location as a wafer front face or a wafer — again — an optical lens — a passage — a mark on said reticle — pass — a beam of light — there was the approach of make luminous intensity a valuation basis and make it into a focus location with an optical location with the maximum point of the luminous intensity .
Moreover, this applicant has proposed the following automatic-focusing doubling approaches by JP,1-299582,A previously. An object including the background which picturizes this automatic-focusing doubling approach to a camera through optical system, Put a predetermined aperture on the inside of the quantized two-dimensional image data, and it differentiates to the image data in the aperture in the direction of both screen top length, width, or every direction. It asks for the differential absolute value gray level histogram which makes frequency the number of pixels to differential absolute value concentration from the differential absolute value image data obtained by taking an absolute value. Cumulative distribution are taken in the direction of differential absolute value concentration zero from the maximum of differential absolute value concentration, and the differential absolute value concentration point whose accumulation corresponds with the number of pixels of a predetermined rate to the number of the before pixels in an aperture is made into the 1st point. Furthermore, in quest of a center of gravity, it is made into the 2nd point to the part of said histogram of said bigger differential concentration absolute value direction than the 1st point, and it asks for distribution of the circumference of said 2nd point from the same part of said histogram. It is the approach characterized by making into a focus location the optical location where the dependency of said 1st point when changing the optical location to an object, said 2nd point, or said distribution is searched for at this time, and said 1st point, 2nd point, or said distribution serves as max, respectively. [said]
[Problem(s) to be Solved by the Invention]
In the contraction projection aligner, the automatic-focusing doubling approach for making a wafer side agree in a focal plane (image surface of exposure optical system) serves as an important theme. However, since the automatic focus approach in the conventional aligner was automatic-focusing doubling (it is hereafter called a baked focus) to the time of exposure by the ultraviolet radiation for exposure, the intermediary had not mentioned relation with the focusing

point in relative-position doubling which performs alignment.
On the other hand, this invention person was dependent on change of various kinds of wafer surface materials with which the focus location for exposure and the optimal optical location for alignment generally occur between semi-conductor production processes, and resist thickness, absorption of a resist, etc., the focus location of exposure light and the detection light for alignment was not necessarily in agreement, and it found out changing in the range of maximum number mum according to a process. Such an optical location difference of the direction of an optical axis may blur the image of the mark for alignment on said wafer, may drop the precision of alignment as a result, and may be in the so-called incorrect detection or detection disabling depending on extent. Especially if this phenomenon has the wavelength difference of exposure light and alignment detection light, it will pose a problem.
Moreover, correspondence with the wafer mark image to an optical location picturized becomes as it is shown in Fig. 3 . Fig. 3 (a) is a mimetic diagram of one mark cross section among the alignment mark of a wafer. In this drawing, in 31, a resist and 30 show a wafer and 32 shows interference with a resist front face and a wafer front face. Moreover, the luminous-intensity distribution corresponding to drawing (a) of the image picturized when Z1, Z2, Z3, and Z4 show an optical location, respectively and each is made to focus is drawing (b), (c), (d), and (e). Like illustration, these mark images picturized are sensitive to optical location change because of interference of the multiple echo light from the resist front face from a wafer front face. This is directly reflected in the detection precision of alignment, and alignment precision also changes with the changing luminous-intensity distribution.
Such a phenomenon is becoming remarkable by using the technique of an image processing of using an image sensor as the technique of alignment. It exists in the background of this invention that it is necessary especially with detailed-izing of a pattern to use the image of the optical location optimized as an image for alignment when alignment precision was becoming severe.
It burned and, in the case of the focus, aimed at how it defines within the section which are the technical problems [that its attention was paid in the conventional approach] which how centralizes exposure luminous energy on a resist, and is shown in Fig. 3 by 33, the focus, i.e., the baking focus, of exposure optical system. For example, when using a multilayer resist, the absorption layer of exposure wavelength exists in the location near a substrate side, and a sensitization layer is shown in a resist front face. Therefore, a baked focal location is near the front face of a resist. On the other hand, although the location of the baking focus in a monolayer resist is based also on the breeching property of a resist, it is known that it is close to a substrate side. Therefore, the location of a baked focus is greatly influenced by the process and substrate conditions of a resist to be used.
On the other hand, the suitable optical location for alignment is a location where alignment is called for with the most sufficient precision, and the focal location of the image pick-up optical system at that time is not necessarily burned, and does not agree with a focal location. The dependency over the thickness class of a resist of location (namely, best focus for alignment) which tells the information on a wafer substrate side by alignment optical system, the substrate conditions of a wafer, etc., and the process of the above resists which can be burned and come out and the dependency of the best focus location to the substrate conditions of a wafer exist independently, and this is produced according to each relation not being dense. It has become impossible for a focus to be severe, to be burned like before and to divert a focal location to alignment as it is by the alignment using an image, especially.
This invention aims at enabling it to perform alignment of the exposed body, equipment or the exposed body, and the original edition with a more sufficient precision in the aligner which performs alignment detection with the exposed bodies, such as a wafer, equipment or the exposed body, and the original editions, such as a reticle, using the optical information which passed through alignment detection optical system.
[Means for Solving the Problem and its Function]
The aligner of this invention is characterized by for the automatic-focusing doubling equipment for exposure to form independently the automatic-focusing doubling equipment for alignment which detects a focal location based on the picture signal of the mark for [which is obtained by

the optical system and the image sensor for alignment] alignment in the aligner which performs alignment detection with the exposed body, equipment or the exposed body, and the original edition using the optical information which passed through alignment detection optical system. It is what specifically performs alignment detection (relative-position-related detection) with the exposed body, equipment or the exposed body, and the original edition in the following examples using the optical information which passed through alignment detection optical system. In case alignment of the exposed body, equipment or the exposed body, and the original edition is performed, he is trying for the optimal optical location at the time of exposure to ask for the optimal optical location of said exposed body in alignment detection optical system independently so that alignment can be performed with a sufficient precision. Therefore, before performing said alignment detection, in the adoption location of one point or several points on the exposed body, the optical location of the exposed body is changed and "the electrical signal with which the optical location of the exposed body and relation were attached from the alignment mark optical information on the exposed body which passed through alignment detection optical system" is measured. And it asks for the optimal above optical location from each point on the exposed body from the functional description in the **-less ** case as a function which depends for the electrical signal of each optical location of exposed body top each point on an optical location. Statistics processing of the optical location of each point for which it asked was carried out as information on each point on the exposed body, the optical location of the acquired exposed body was memorized as an optimal optical location to alignment, and the focusing means for exposure and another kind are equipped with a means to make the exposed body drive to this optimal optical location again at coincidence.
Thereby, the optimal optical location for alignment can be determined independently of 1 baking focus.
2) An alignment mark can be used as the object of optical location detection, the same image pick-up system as alignment can be used for coincidence, and the best optical location can be directly known for alignment in this case.
3) By adopting the technique of statistics processing, an approach utilizable also not only to the maximum point corresponding to the focusing point of an automatic-focusing performance index but other stationary points is offered, and, for this reason, the suitable optical location for alignment can be determined depending on the alignment approach used at the time of alignment.

4) The outlying observation of the exposed inside of the body can be removed, and the reliability of the optimal optical location finally obtained increases.
5) Since the noise which comes from the configuration of the exposed body according to the equalization effectiveness can be removed, the alignment optimal optical location by exposed body each for which only the semi-conductor production process depended can be determined.
The effectiveness of ** is acquired.
[Example]
Hereafter, the example of this invention is explained using an accompanying drawing.
Fig. 1 is a conceptual diagram of the contraction projection aligner concerning one example of this invention.
The contraction aligner of this drawing reduces and imprints a circuit pattern at a rate of 1 to 5 to a wafer using exposure light
In this drawing, R is a reticle and is held in the reticle stage 12. W is a wafer and the mark M for alignment for performing alignment of equipment and a wafer is on Wafer W. The reducing glass with which 10 constitutes a XYZ-stage and 11 constitutes projection optics, In 12, a reticle stage and 13 a reference mark and 15 for a mirror and 14 An orientation plate, In 16, an objective lens and 17 an illumination-light study system and 19 for a half mirror and 18 A mirror, In 110, laser and 111 image pick-up equipment and 113 for image pick-up optical system and 112 A/D-conversion equipment, A differential absolute value histogram arithmetic unit and 115 114 An evaluation value arithmetic unit, An automatic-focusing doubling control unit and 117 116 The automatic-focusing doubling equipment for exposure light, 118 — for the aperture for automatic-focusing doubling, and 30, as for a resist and 32, a wafer and 31 are [the mark for automatic-

focusing doubling for exposure light, and 119 / the datum plane of a XYZ stage, and 20 / interference of the reflected light in a resist and a wafer and 33] the focal locations of exposure light. A mirror 13, an orientation plate 15, an objective lens 16, a half mirror 17, the illumination-light study system 18, a mirror 19, laser 110, the image pick-up optical system 111, and image pick-up equipment 112 constitute the automatic-focusing doubling detection optical system for alignment, and this automatic-focusing doubling detection optical system and A/D-conversion equipment 113, the differential absolute value histogram arithmetic unit 114, the evaluation value arithmetic unit 115, and the automatic-focusing doubling control unit 116 constitute the automatic-focusing doubling equipment for alignment. Here, the above-mentioned optical system of the automatic-focusing doubling equipment for alignment is carrying out the object for the averages of the same optical system as the alignment detection system which uses an image, and the image pick-up equipment.

The contraction aligner of Fig. 1 reduces and imprints a circuit pattern at a rate of 1 to 5 to a wafer using exposure light. Moreover, it has the same automatic-focusing doubling equipment 117 for exposure light as Japanese Patent Application No. 63-258555, and can amend by moving the XYZ stage 10, the relation, i.e., the baking focus, of the mark 118 for automatic-focusing doubling for exposure light on Reticle R, the location of 33 of Fig. 3 , and the datum-level 119 top optically located in the same location. Here, this automatic-focusing doubling equipment 117 for exposure light and the optical positional controller system for alignment described below are prepared independently.

Next, the automatic-focusing doubling detection optical system used in the case of the alignment of Wafer W and equipment is explained along Fig. 1 . In this example, the laser light source 110 is used as a source of the illumination light for alignment. The light emitted from the laser light source 110 passes along the orientation plate 15 and mirror 13 which were fixed to an objective lens 16 and equipment, after changing a direction by the half mirror 17 through a mirror 19 and the illumination-light study system 18, it irradiates alignment mark M on a wafer through reducing glass 11 further, and is reflected on a wafer side. Said reflected light passes along the image pick-up optical system 111, after passing through reducing glass 11, a mirror 13, an orientation plate 15, an objective lens 16, and a half mirror 17, and it is received by image pick-up equipment 112. The alignment mark image on a wafer is then picturized like 2nd [**] Fig. M'. It can move in the direction of an optical axis, and the XYZ-stage 10 is controlled by the automatic-focusing doubling control unit 116. Focusing for alignment in the alignment of a wafer and equipment makes the above-mentioned XYZ-stage 10 drive in the direction of an optical axis, and performs it. Moreover, there is a reference mark 14 in the orientation plate 15 fixed to equipment, by adjusting the image pick-up optical system 111, the orientation plate 15 was optically used as image pick-up equipment 112 conjugate, it depended reference mark 14, and a change of image pick-up equipment 112 with time is amended periodically.

The focusing points in an image pick-up system differ with extent of several micrometers depending on change of the wafer surface material which occurs between semi-conductor production processes, and change of the thickness of a resist.

On the other hand, the suitable optical location for alignment is divided into the suitable location Z4, the mid-position of both points, and the location at the still more nearly other point focusing [un-] when it pays its attention to the constructional detail of the location Z1 suitable when it pays its attention to the image of the whole mark (Fig. 3 (b)), and a body depending on the alignment approach (Fig. 3 (d)). Therefore, the suitable optical alignment to the alignment of a wafer and equipment must correspond to the three-dimensional structure of the alignment mark on a wafer strictly.

The differential absolute value gray-level-histogram approach shown as the automatic optimal optical alignment approach of having taken three-dimension-structure into consideration, by Japanese Patent Application No. No. 299582 [one to] explained previously is used.

The aligner of Fig. 1 is equipped with a non-illustrated central processing unit (CPU), and that whole actuation is performed to the bottom of control of this CPU.

Hereafter, the flow of the above-mentioned whole automatic-focusing doubling actuation for alignment is explained along Fig. 4 .

Said CPU makes an optical axis and a perpendicular direction (the XY direction) drive the XYZ stage 10 with the automatic-focusing doubling control unit 116 as initialization (step 401) first, and alignment mark M which exists in the suitable location on a wafer is picturized. The wafer is having rough alignment already performed to about several micrometers at this time.
As shown in Fig. 5 on a wafer, two or more alignment mark M is formed in each location of 51-55, respectively. Here, the mark currently formed in the location of one of these marks, 51 [for example,] of Fig. 5 , is picturized.
Next, at step 403, predetermined makes the distance migration of the XYZ stage 10 carry out in the predetermined direction in accordance with an optical axis (Z-axis) with the automatic-focusing doubling control device 116, and the optical location of the XYZ stage 10 is memorized to coincidence. Furthermore, the image picturized using said automatic-focusing doubling detection optical system 100 and 13-19, the image pick-up optical system 111, and image equipment 112 is memorized as two-dimensional image data quantized by A/D-conversion equipment 113. Here, the aperture 20 (Fig. 2) which comes on a wafer mark after alignment as an aperture for automatic-focusing doubling is chosen. the differential absolute value histogram arithmetic unit 114 — setting — the image data in an aperture 20 — receiving — a reference mark and a perpendicular direction (Fig. 2 , space longitudinal direction) — difference — it is made to take an absolute value (differential absolute value), and differential absolute value image data is obtained. In the differential absolute value histogram arithmetic unit 114, the differential absolute value gray level histogram made into frequency is obtained [number / of pixels] by the axis of abscissa in the differential absolute value concentration currently quantized to this differential absolute value image data. Then, cumulative distribution are taken in the direction of zero from differential absolute value concentration maximum, and differential absolute value concentration which is in agreement with the number of pixels which becomes twice [r (r< 1)] the number of pixels in said aperture 20 is made into p points. From p points, a center of gravity g is searched for from said upper histogram, and it considers as the evaluation value g. A center of gravity g is made to memorize with the optical location z of the XYZ stage sent from the automatic-focusing doubling control device 116 in the evaluation value arithmetic unit 115. Next, with the automatic-focusing doubling control device 116, the XYZ stage 10 is driven and the XYZ stage 10 is changed to the time of a setup of the beginning of an optical axis, and hard flow at the predetermined spacing. The location of a XYZ-stage is returned to the automatic-focusing doubling control unit 116. It is made said this appearance to the location (optical location) z of the XYZ-stage which changed, and the center of gravity g of a histogram is searched for. According to said array of g and a location z memorized by the evaluation value arithmetic unit 115, a center of gravity g serves as a function of a location z, and draws a focusing evaluation curve as shown in Fig. 6 to change of the optical location z. It is for the three-dimensional structure of the alignment mark of a wafer that a curve is not a candidate for right and left. whether when the property at the time of un-focusing by the alignment approach is known beforehand, its attention is paid to the fine structure (structure where a frequency is high), by changing said rate r, and a game — it is distinguishable whether its attention is paid to the-like structure (structure where a frequency is low).
Then, the rate r which determines the most suitable optical location for the alignment approach to be used can be drawn according to automatic-focusing doubling used by this example.
Moreover, to determined r, it cannot be dependent on the difference between semi-conductor processes, and an optical location where an image with the almost same frequency component is obtained can be determined.
Moreover, the optimal optical location of the alignment approach can be determined by searching for a focusing point, asking for stationary points other than a maximum point, or calculating the minimal value from the differential function of a performance index by the circumference of maximum, according to the form of the computed performance index (Fig. 6) using a interpolation means.

* NOTICES *

TECHNICAL FIELD

[Industrial Application]
This invention relates to the aligner with which the optimal optical location of the alignment mark at the time of detecting the relative-position relation between the original editions, such as the exposed bodies, such as a wafer, equipment, or a reticle, and the exposed body especially was doubled automatically about the aligner used for printing, such as a semi-conductor pattern.

[Translation done.]

* NOTICES *

PRIOR ART

[Description of the Prior Art]
In recent years, in a projection aligner, the alignment approach that precision is high, and the focusing approach that precision is high have been needed by the demand of detailed-izing of patterns, such as a semiconductor device, an LSI component, and a VLSI component, and high integration.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]
In the contraction projection aligner, the automatic-focusing doubling approach for making a wafer side agree in a focal plane (image surface of exposure optical system) serves as an important theme. However, since the automatic focus approach in the conventional aligner was automatic-focusing doubling (it is hereafter called a baked focus) to the time of exposure by the ultraviolet radiation for exposure, the intermediary had not mentioned relation with the focusing point in relative-position doubling which performs alignment.
On the other hand, this invention person was dependent on change of various kinds of wafer surface materials with which the focus location for exposure and the optimal optical location for alignment generally occur between semi-conductor production processes, and resist thickness, absorption of a resist, etc., the focus location of exposure light and the detection light for alignment was not necessarily in agreement, and it found out changing in the range of maximum number mum according to a process. Such an optical location difference of the direction of an optical axis may blur the image of the mark for alignment on said wafer, may drop the precision of alignment as a result, and may be in the so-called incorrect detection or detection disabling depending on extent. Especially if this phenomenon has the wavelength difference of exposure light and alignment detection light, it will pose a problem.
Moreover, correspondence with the wafer mark image to an optical location picturized becomes as it is shown in Fig. 3 . Fig. 3 (a) is a mimetic diagram of one mark cross section among the alignment mark of a wafer. In this drawing, in 31, a resist and 30 show a wafer and 32 shows interference with a resist front face and a wafer front face. Moreover, the luminous-intensity distribution corresponding to drawing (a) of the image picturized when Z1, Z2, Z3, and Z4 show an optical location, respectively and each is made to focus is drawing (b), (c), (d), and (e). Like illustration, these mark images picturized are sensitive to optical location change because of interference of the multiple echo light from the resist front face from a wafer front face. This is directly reflected in the detection precision of alignment, and alignment precision also changes with the changing luminous-intensity distribution.
Such a phenomenon is becoming remarkable by using the technique of an image processing of using an image sensor as the technique of alignment. It exists in the background of this invention that it is necessary especially with detailed-izing of a pattern to use the image of the optical location optimized as an image for alignment when alignment precision was becoming severe.
It burned and, in the case of the focus, aimed at how it defines within the section which are the technical problems [that its attention was paid in the conventional approach] which how centralizes exposure luminous energy on a resist, and is shown in Fig. 3 by 33, the focus, i.e., the baking focus, of exposure optical system. For example, when using a multilayer resist, the absorption layer of exposure wavelength exists in the location near a substrate side, and a sensitization layer is shown in a resist front face. Therefore, a baked focal location is near the front face of a resist. On the other hand, although the location of the baking focus in a monolayer resist is based also on the breeching property of a resist, it is known that it is close to a substrate side. Therefore, the location of a baked focus is greatly influenced by the process and substrate conditions of a resist to be used.

On the other hand, the suitable optical location for alignment is a location where alignment is called for with the most sufficient precision, and the focal location of the image pick-up optical system at that time is not necessarily burned, and does not agree with a focal location. The dependency over the thickness class of a resist of location (namely, best focus for alignment) which tells the information on a wafer substrate side by alignment optical system, the substrate conditions of a wafer, etc., and the process of the above resists which can be burned and come out and the dependency of the best focus location to the substrate conditions of a wafer exist independently, and this is produced according to each relation not being dense. It has become impossible for a focus to be severe, to be burned like before and to divert a focal location to alignment as it is by the alignment using an image, especially.
This invention aims at enabling it to perform alignment of the exposed body, equipment or the exposed body, and the original edition with a more sufficient precision in the aligner which performs alignment detection with the exposed bodies, such as a wafer, equipment or the exposed body, and the original editions, such as a reticle, using the optical information which passed through alignment detection optical system.

[Translation done.]

OPERATION

[Means for Solving the Problem and its Function]
The aligner of this invention is characterized by for the automatic-focusing doubling equipment for exposure to form independently the automatic-focusing doubling equipment for alignment which detects a focal location based on the picture signal of the mark for [which is obtained by the optical system and the image sensor for alignment] alignment in the aligner which performs alignment detection with the exposed body, equipment or the exposed body, and the original edition using the optical information which passed through alignment detection optical system.
Specifically in the following examples, alignment detection (relative-position-related detection) with the exposed body, equipment or the exposed body, and the original edition is performed using the optical information which passed through alignment detection optical system, In case alignment of the exposed body, equipment or the exposed body, and the original edition is performed, he is trying for the optimal optical location at the time of exposure to ask for the optimal optical location of said exposed body in alignment detection optical system independently so that alignment can be performed with a sufficient precision. Therefore, before performing said alignment detection, in the adoption location of one point or several points on the exposed body, the optical location of the exposed body is changed and "the electrical signal with which the optical location of the exposed body and relation were attached from the alignment mark optical information on the exposed body which passed through alignment detection optical system" is measured. And it is a function which depends for the electrical signal of each optical location of exposed body top each point on an optical location. It asks for the optimal above optical location from each point on the exposed body from the functional description in the **-less ** case. Statistics processing of the optical location of each point for which it asked was carried out as information on each point on the exposed body, the optical location of the acquired exposed body was memorized as an optimal optical location to alignment, and the focusing means for exposure and another kind are equipped with a means to make the exposed body drive to this optimal optical location again at coincidence.
Thereby, the optimal optical location for alignment can be determined independently of 1 baking focus.
2) An alignment mark can be used as the object of optical location detection, the same image pick-up system as alignment can be used for coincidence, and the best optical location can be directly known for alignment in this case.
3) By adopting the technique of statistics processing, an approach utilizable also not only to the maximum point corresponding to the focusing point of an automatic-focusing performance index but other stationary points is offered, and, for this reason, the suitable optical location for alignment can be determined depending on the alignment approach used at the time of alignment.

4) The outlying observation of the exposed inside of the body can be removed, and the reliability of the optimal optical location finally obtained increases.
5) Since the noise which comes from the configuration of the exposed body according to the equalization effectiveness can be removed, the alignment optimal optical location by exposed body each for which only the semi-conductor production process depended can be determined.

The effectiveness of ** is acquired.

[Translation done.]

EXAMPLE

[Example]
Hereafter, the example of this invention is explained using an accompanying drawing.
Fig. 1 is a conceptual diagram of the contraction projection aligner concerning one example of this invention.
The contraction aligner of this drawing reduces and imprints a circuit pattern at a rate of 1 to 5 to a wafer using exposure light.
In this drawing, R is a reticle and is held in the reticle stage 12. W is a wafer and the mark M for alignment for performing alignment of equipment and a wafer is on Wafer W. The reducing glass with which 10 constitutes a XYZ-stage and 11 constitutes projection optics, In 12, a reticle stage and 13 a reference mark and 15 for a mirror and 14 An orientation plate, In 16, an objective lens and 17 an illumination-light study system and 19 for a half mirror and 18 A mirror, In 110, laser and 111 image pick-up equipment and 113 for image pick-up optical system and 112 A/D-conversion equipment, A differential absolute value histogram arithmetic unit and 115 114 An evaluation value arithmetic unit, An automatic-focusing doubling control unit and 117 116 The automatic-focusing doubling equipment for exposure light, 118 — for the aperture for automatic-focusing doubling, and 30, as for a resist and 32, a wafer and 31 are [the mark for automatic-focusing doubling for exposure light, and 119 / the datum plane of a XYZ stage, and 20 / interference of the reflected light in a resist and a wafer and 33] the focal locations of exposure light.

* NOTICES *

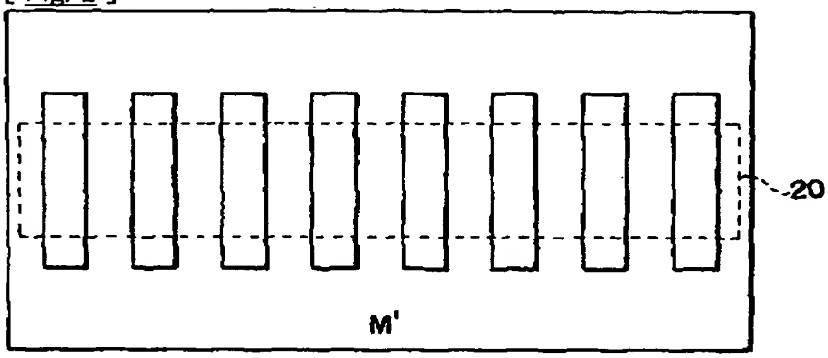
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
Fig. 1 is an important section schematic diagram of the contraction projection aligner concerning one example of this invention,
Fig. 2 is an explanatory view showing the image picturized in the equipment of Fig. 1 at the time of the alignment of a wafer mark,
Fig. 3 is an explanatory view showing the relation between the optical location of the sectional view of a wafer, and an image pick-up system, and the image picturized,
Fig. 4 is a flow chart of the automatic-focusing doubling actuation for alignment in the equipment of Fig. 1 ,
Fig. 5 is a plot plan of the alignment mark on the wafer used by this example,
Fig. 6 is a graph which shows the example of the automatic-focusing doubling performance index over a wafer mark.
W: Wafer
R: Reticle
M: The alignment mark on a wafer
M': The alignment mark image on a wafer
10: XYZ-stage
11: Projection optics
12: Reticle stage
13: Mirror
14: Reference mark
15: Orientation plate
16: Objective lens
17: Half mirror
18: Illumination-light study system
19: Mirror
110: Laser light source
111: Image pick-up optical system
112: Image pick-up equipment
113: A/D-conversion equipment
114: Differential absolute value histogram arithmetic unit
115: Evaluation value arithmetic unit
116: Automatic-focusing doubling control unit
117: Automatic-focusing doubling equipment for exposure light
118: The mark for automatic-focusing doubling for exposure light
119: Datum level of a XYZ stage
20: The aperture for automatic-focusing doubling
30: Wafer
31: Resist
32: Interference of the reflected light in a resist and a wafer
33: The focal location of exposure light

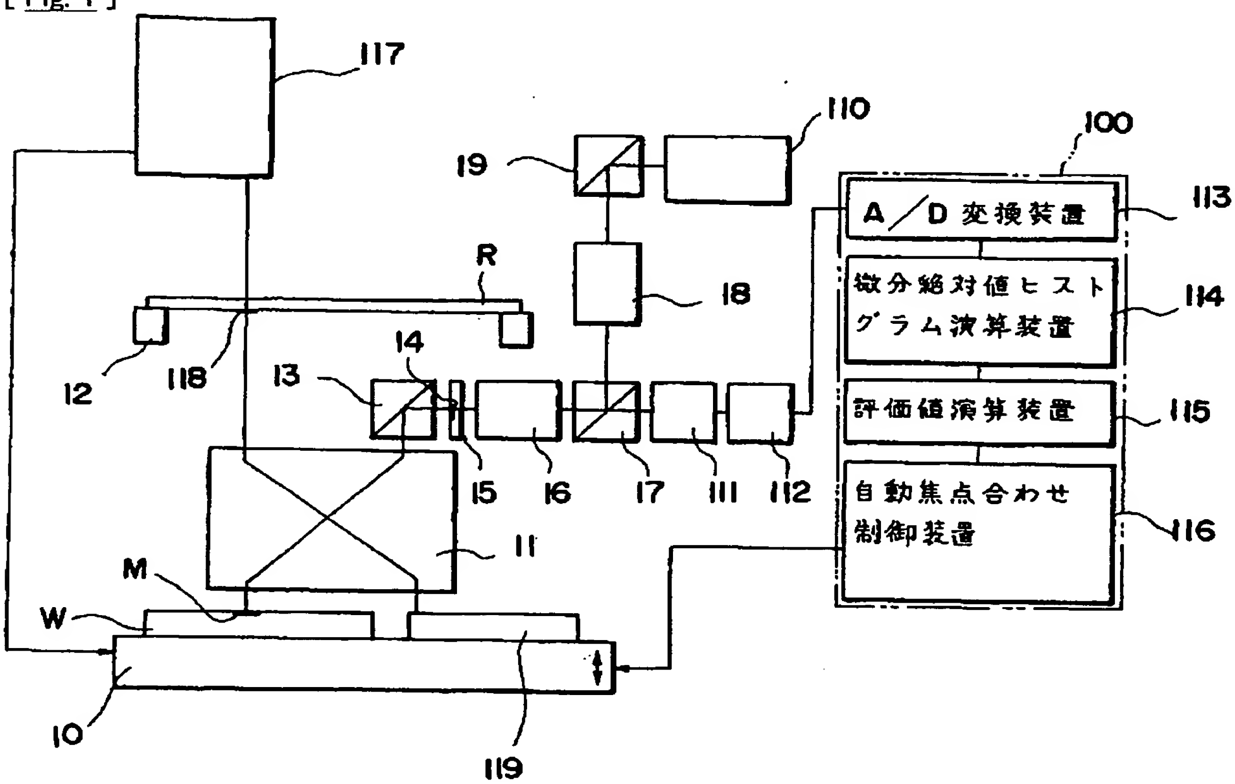
[Translation done.]

DRAWINGS

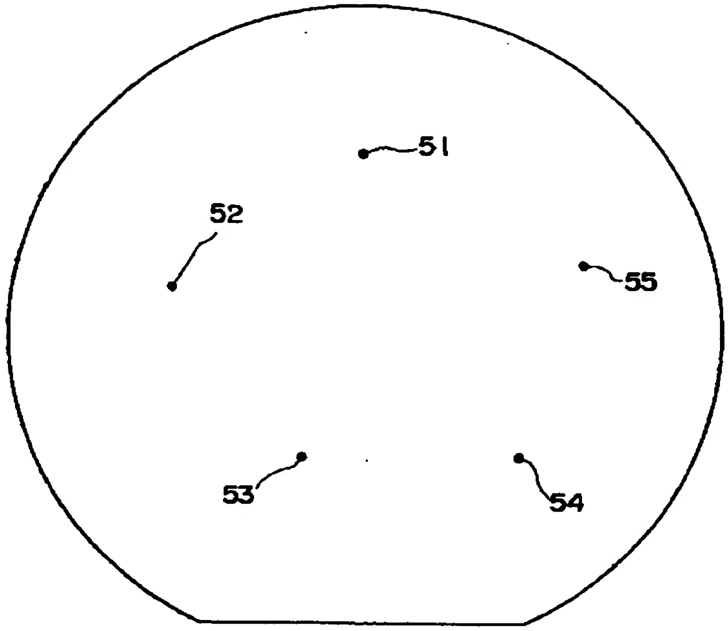
[Fig. 2]



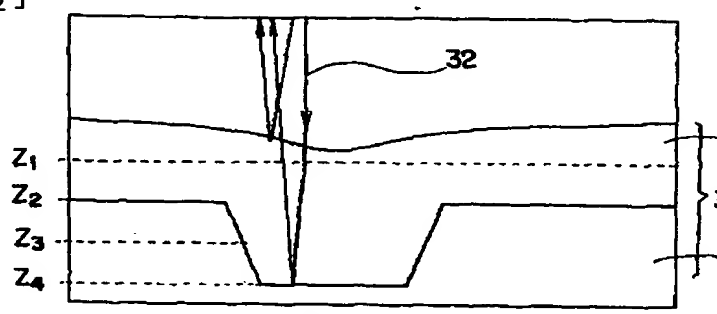
[Fig. 1]



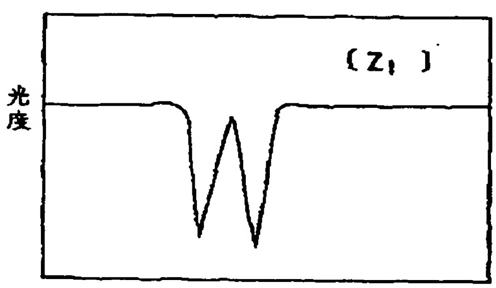
[Fig. 5]



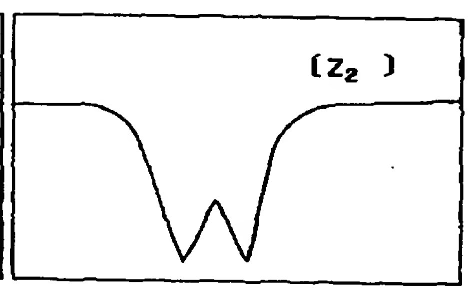
[Fig. 3]



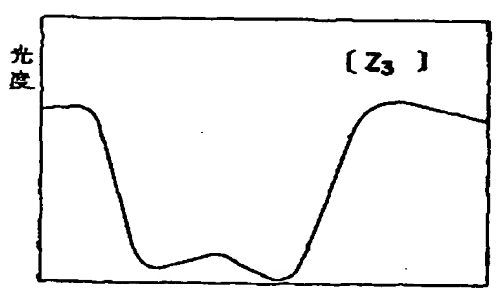
(a)



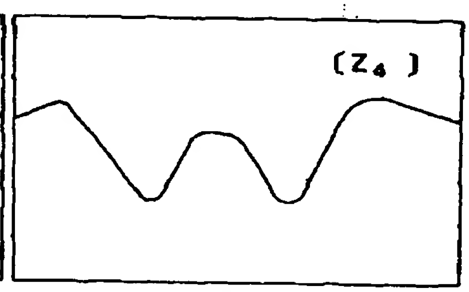
(b)



(c)

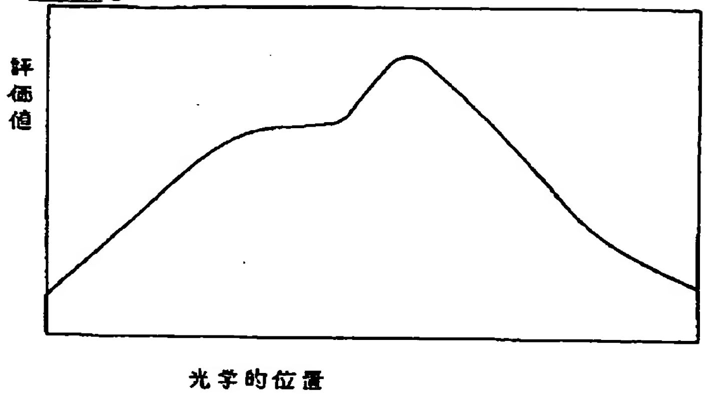


(d)

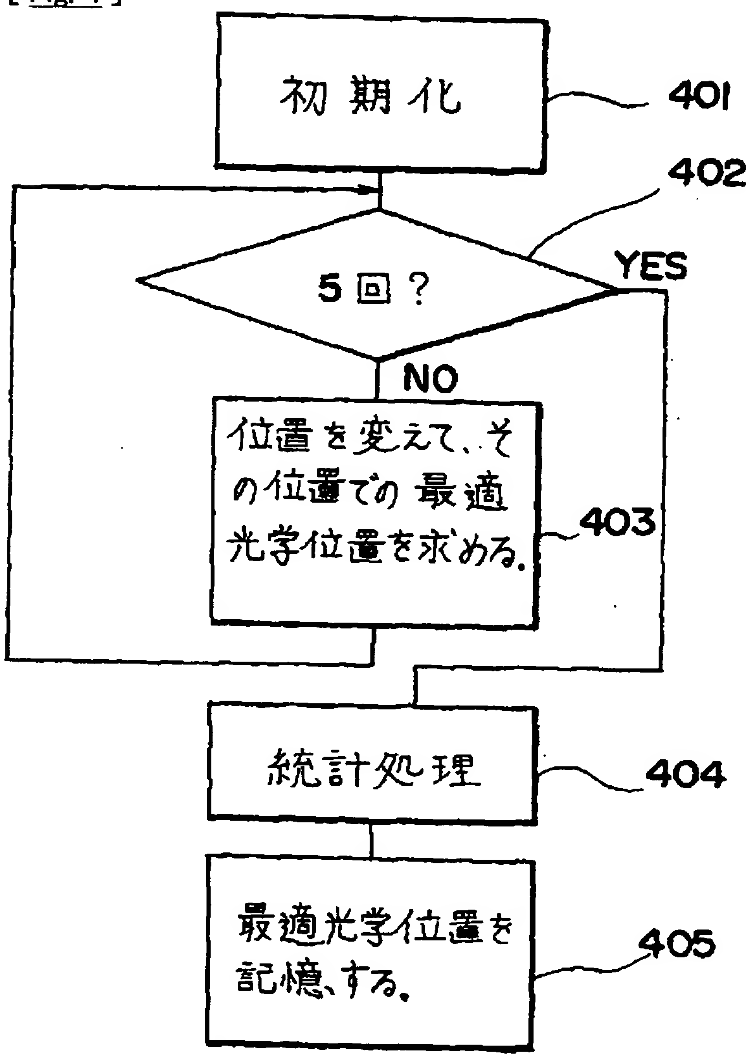


(e)

[Fig. 6]



[Fig. 4]



[Translation done.]

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㊹発明の名称　露光装置

㉑特　願　平2－127004

㉒出　願　平2(1990)5月18日

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明　細　書

1．発明の名称

露光装置

2．特許請求の範囲

（1）被露光体と装置あるいは被露光体と原版との位置合わせ検出を位置合わせ検出光学系を経た光学情報を利用して行なう露光装置において、

位置合わせ用の自動焦点合わせ装置を露光用の自動焦点合わせ装置とは独立に設けたことを特徴とする露光装置。

（2）前記位置合わせ用の自動焦点合わせ装置は、位置合わせ用のマークを位置合わせ用の光学系と撮像素子とによって得られる画像信号に基づいて、焦点位置を検出するものである請求項1の露光装置。

（3）前記位置合わせ用の自動焦点合わせ装置は、前記被露光体内の数ショットにおいてその焦点位置を計測し、統計処理により位置合わせに最適な被露光体の光学位置を検出するものである請求項2の露光装置。

3．発明の詳細な説明

［産業上の利用分野］

本発明は、半導体パターン等の焼付に用いられる露光装置に関し、特に、ウエハ等の被露光体と装置またはレチクル等の原版と被露光体との相対位置関係を検出する際の位置合わせマークの最適光学位置を自動的に合わせるようにした露光装置に関する。

［従来の技術］

近年、半導体素子、LSI素子および超LSI素子等のパターンの微細化および高集積化の要求により、投影露光装置において精度の高い位置合わせ方法や精度の高い焦点合わせ方法が必要とされてきている。

縮小投影露光装置における自動焦点合わせにつ

いては、レチクル上の格子マークに紫外光を当て、露光用光学レンズを経てウエハ表面あるいはウエハと同一光学位置に位置する基準面に反射した後に再び光学レンズを通り前記レチクル上マークを通過する光線の光度を評価基準とし、その光度の最大点を持つ光学的位置をもって合焦位置とする方法があった。

また、本件出願人は先に特願平１－２９９５８２号で以下のような自動焦点合わせ方法を提案している。この自動焦点合わせ方法は、光学系を通してカメラに撮像する背景を含む対象物の、量子化された２次元画像データの内に所定の窓を置き、その窓内の画像データに対して画面上縦または横または縦横両方の方向に微分し、絶対値を取ることによって得られる微分絶対値画像データから微分絶対値濃度に対する画素数を頻度とする微分絶対値濃度ヒストグラムを求め、微分絶対値濃度の最大値より微分絶対値濃度ゼロの方向に累積分布を取り、累積が窓内の全画素数に対して所定の割合の画素数と一致する微分絶対値濃度点を第

１点とする。さらに、前記第１点より大きな微分濃度絶対値方向の前記ヒストグラムの部分に対して重心を求めそれを第２点とし、また前記ヒストグラムの同一部分に対して前記第２点まわりの分散を求める。この時、対象物に対する光学的位置を変化させたときの前記第１点、または前記第２点、または前記分散の依存性を求め、前記第１点または前記第２点または前記分散がそれぞれ最大となる光学位置を合焦位置とすることを特徴とする方法である。

［発明が解決しようとしている課題］

縮小投影露光装置においては、ウエハ面を焦点面（露光光学系の像面）に合致させるための自動焦点合わせ方法が重要なテーマとなっている。しかしながら、従来の露光装置における自動合焦方法は露光用の紫外光による露光時に対する自動焦点合わせ（以下、焼き焦点と呼ぶ）であったため、アライメントを行なう相対位置合わせにおいての合焦点との関係につては言及していなかっ

た。

一方、本発明者は、露光用合焦位置と位置合わせ用最適光学位置が一般に半導体製造工程間で起きる各種のウエハ表面素材およびレジスト厚の変化ならびにレジストの吸収等に依存しており、露光光と位置合わせ用検出光の合焦位置は必ずしも一致せず、工程に応じ最大数μｍの範囲で変動することを見出した。このような光軸方向の光学位置差は、前記ウエハ上の位置合わせ用マークの像をぼやけさせ、結果として位置合わせの精度を落とし、程度によってはいわゆる誤検知または検出不能状態となることがある。この現象は露光光と位置合わせ検出光の波長差があると特に問題となる。

また、光学的位置に対しての撮像されるウエハマーク像との対応は、第３図のようになる。第３図（ａ）はウエハの位置合わせマーク中１本のマーク断面の模式図である。同図において、３１はレジスト、３０はウエハ、３２はレジスト表面とウエハ表面との干渉を示している。また、Z_1、

Z_2、Z_3およびZ_4はそれぞれ光学的位置を示し、各々に合焦させたときに撮像される像の図（ａ）に対応した光度分布が図（ｂ）、（ｃ）、（ｄ）および（ｅ）である。図示のように、これらの撮像されるマーク像はウエハ表面からとレジスト表面からとの多重反射光の干渉のため光学的位置変化に敏感である。このことは、直接、位置合わせの検出精度に反映され、変化する光度分布にともなって位置合わせ精度も変化する。

このような現象はアライメントの手法として撮像素子を用いる画像処理の手法が用いられることによって顕著になってきた。特にパターンの微細化に伴い、アライメント精度が酷しくなってきたことによりアライメント用の画像として最適化された光学的位置の像を用いる必要があることが本発明の背景には存在している。

従来の方法において着目されていた焼き焦点の場合は、如何に露光光のエネルギーをレジストに集中させるかが課題であり、第３図に３３で示す

区間内に露光光学系の焦点、つまり焼き焦点を如何に定めるかを目的としていた。例えば多層レジストを用いる場合、基板面に近い位置には露光波長の吸収層が存在しており、感光層はレジスト表面にある。したがって、焼き焦点位置はレジストの表面近傍にある。一方、単層レジストでの焼き焦点の位置はレジストのブリーチング特性にもよるが、基板面に近いことが知られている。したがって、焼き焦点の位置は使用するレジストのプロセスや基板条件によって大きく左右される。

他方、位置合わせにとっての適切な光学位置は、位置合わせが最も精度良く求められる位置のことであり、その時の撮像光学系の焦点位置は必ずしも焼き焦点の位置とは合致しない。これは、位置合わせ光学系でウエハ基板面の情報を伝える位置、（すなわち位置合わせ用のベストフォーカス）のレジストの厚さ種類、ウエハの基板条件等に対する依存性と、焼き付けでの前述のようなレジストのプロセスやウエハの基板条件に対するベストフォーカス位置の依存性とが独立に存在し、各々の関係が密でないことにより生じる。特に、画像を用いた位置合わせでは、フォーカスが厳しく、従来のように焼き付け焦点位置をそのまま位置合わせ用に流用することは不可能となってきた。

本発明は、ウエハ等の被露光体と装置あるいは被露光体とレチクル等の原版との位置合わせ検出を、位置合わせ検出光学系を経た光学情報を利用して行なう露光装置において、被露光体と装置あるいは被露光体と原版との位置合わせをより精度良く行ない得るようにすることを目的とする。

［課題を解決するための手段および作用］

本発明の露光装置は、被露光体と装置あるいは被露光体と原版との位置合わせ検出（相対位置関係の検出）を位置合わせ検出光学系を経た光学情報を利用して行なうもので、被露光体と装置あるいは被露光体と原版との位置合わせを行なう際に位置合わせを精度良く行ない得るように、位置合わせ検出光学系における前記被露光体の最適な光学的位置を露光時の最適光学位置とは独立に求めるようにしている。そのため、前記位置合わせ検出を行なう以前に、被露光体上の1点あるいは数点の採用位置において、被露光体の光学位置を変化させ、「位置合わせ検出光学系を経た被露光体上の位置合わせマーク光学情報より、被露光体の光学位置と関係の付けられた電気信号」を測定する。そして、被露光体上各点の各々の光学位置の電気信号を光学位置に依存する関数として倣なした際のその関数的特徴より前記の最適な光学位置を被露光体上の各点に対して求め、求めた各点の光学位置を被露光体上の各点の情報として統計処理し、得た被露光体の光学位置を位置合わせに対して最適光学位置として記憶し、被露光体を該最適光学位置へ駆動させる手段を露光用焦点合わせ手段と別種にまた同時に備えている。

これにより、

1）焼き焦点とは独立に位置合わせ用最適光学位置を決定し得る。

2）位置合わせマークを光学位置検出の対象物とし、同時に位置合わせと同一の撮像系を使用することができ、この場合、位置合わせにとって最も良い光学位置を直接知り得る。

3）統計処理の手法を採用することによって、自動焦点評価関数の合焦点に対応する最大値点のみでなく、他の停留点に対しても活用できる方法が提供され、このため、位置合わせ時に使用する位置合わせ方法に依存して位置合わせに適切な光学位置を決定し得る。

4）被露光体内の異常値を取り除くことが出来、最終的に得た最適光学位置の信頼度が高まる。

5）平均化効果によって被露光体の形状から来るノイズを除去し得るため、被露光体個々によらない、半導体製造工程のみ依存した位置合わせ最適光学位置を決定し得る。

等の効果が得られる。

［実施例］

以下、添付図面を用いて本発明の実施例を説明する。

第１図は、本発明の一実施例に係る縮小投影露光装置の概念図である。

同図の縮小露光装置は、露光光を使用して回路パターンをウエハに１対５の割合で縮小して転写するものである。

同図において、Ｒはレチクルであり、レチクルステージ１２に保持されている。Ｗはウエハであり、ウエハＷ上には装置とウエハとの位置合わせを行なうための位置合わせ用マークＭがある。１０はＸＹＺ－ステージ、１１は投影光学系を構成する縮小レンズ、１２はレチクルステージ、１３はミラー、１４は基準マーク、１５は基準板、１６は対物レンズ、１７はハーフミラー、１８は照明光学系、１９はミラー、１１０はレーザ、１１１は撮像光学系、１１２は撮像装置、

１１３はＡ／Ｄ変換装置、１１４は微分絶対値ヒストグラム演算装置、１１５は評価値演算装置、１１６は自動焦点合わせ制御装置、１１７は露光光用自動焦点合わせ装置、１１８は露光光用自動焦点合わせ用マーク、１１９はＸＹＺステージの基準面、２０は自動焦点合わせ用窓、３０はウエハ、３１はレジスト、３２はレジストおよびウエハでの反射光の干渉、３３は露光光の焦点位置である。ミラー１３、基準板１５、対物レンズ１６、ハーフミラー１７、照明光学系１８、ミラー１９、レーザ１１０、撮像光学系１１１、および撮像装置１１２は、位置合わせ用自動焦点合わせ検出光学系を構成しており、この自動焦点合わせ検出光学系ならびにＡ／Ｄ変換装置１１３、微分絶対値ヒストグラム演算装置１１４、評価値演算装置１１５および自動焦点合わせ制御装置１１６は、位置合わせ用自動焦点合わせ装置を構成している。ここで、位置合わせ用自動焦点合わせ装置の上記光学系は画像を使用する位置合わせ検出系と同一の光学系および撮像装置を並用している。

第１図の縮小露光装置は、露光光を使用して回

路パターンをウエハに１対５の割合で縮小して転写するものである。また、特願昭６３－２５８５５５と同様の露光光用自動焦点合わせ装置１１７を有し、ＸＹＺステージ１０を移動させることによって、レチクルＲ上の露光光用自動焦点合わせ用マーク１１８と第３図の３３の位置と光学的に同様の位置に位置する基準面１１９上との関係、すなわち焼き焦点を補正し得る。ここで、この露光光用自動焦点合わせ装置１１７と、次に述べる位置合わせ用光学位置制御装置系とは独立に用意されている。

次に、ウエハＷと装置との位置合わせの際に使用する自動焦点合わせ検出光学系について第１図に沿って説明する。本実施例では位置合わせ用の照明光源としてレーザ光源１１０を使用している。レーザ光源１１０から発せられた光は、ミラー１９および照明光学系１８を経てハーフミラー１７で方向を変更した後に対物レンズ１６、装置に固定された基準板１５およびミラー１３を通り、さらに縮小レンズ１１を介してウエハ上の位置合わせマークＭを照射し、ウエハ面上で反射

される。前記反射光は、縮小レンズ１１、ミラー１３、基準板１５、対物レンズ１６およびハーフミラー１７を経た後に撮像光学系１１１を通り、撮像装置１１２に受光される。その時、ウエハ上の位置合わせマーク像は第２図Ｍ'のように撮像される。ＸＹＺ－ステージ１０は、光軸方向に移動でき、自動焦点合わせ制御装置１１６によって制御されている。ウエハと装置との位置合わせにおける位置合わせ用の焦点合わせは上述のＸＹＺ－ステージ１０を光軸方向に駆動させて行なう。また、装置に固定された基準板１５には基準マーク１４があり、撮像光学系１１１を調節することによって基準板１５を撮像装置１１２と光学的に共役にし、基準マーク１４よって定期的に撮像装置１１２の経時的変化を補正している。

撮像系における合焦点は、半導体製造工程間で起きるウエハ表面素材の変化およびレジストの厚さの変化に依存して数μｍの程度で異なっている。

他方、位置合わせにとっての適切な光学的位置

は、その位置合わせ方法に依存し、マーク全体の像に着目する場合（第３図（ｂ））に適切な位置Z_1、物体の細部構造に着目する場合（第３図（ｄ））に適切な位置Z_4、両点の中間位置、さらにそれ以外の非合焦点にある位置に分けられる。したがって、ウエハと装置との位置合わせに対する適切な光学位置合わせはウエハ上の位置合わせマークの３次元構造に厳密に対応しなければならない。

３次元的構造を考慮に入れた自動最適光学的位置合わせ方法として、先に説明した特願平１－２９９５８２号で示された微分絶対値濃度ヒストグラム方法を使用する。

第１図の露光装置は、不図示の中央処理装置（ＣＰＵ）を備え、その全体動作は、このＣＰＵの制御の下に行なわれる。

以下、上記位置合わせ用自動焦点合わせ動作全体の流れを第４図に沿って説明する。

前記ＣＰＵは、先ず、初期設定（ステップ４０１）として、ＸＹＺステージ１０を自動焦点合わせ制御装置１１６により光軸と垂直方向（ＸＹ方向）に駆動させ、ウエハ上の適当な位置に存在する位置合わせマークＭが撮像されるようにする。この時、ウエハは既に数μｍ程度のおおまかな位置合わせを行われているものとする。

ウエハ上には、第５図に示すように複数個の位置合わせマークＭがそれぞれ５１～５５の各位置に形成されている。ここでは、これらのマークのうちの１つ、例えば第５図の５１の位置に形成されているマークを撮像する。

次に、ステップ４０３にて、自動焦点合わせ制御装置１１６によりＸＹＺステージ１０を光軸（Ｚ軸）に沿って所定の方向に所定の距離移動させ、同時にＸＹＺステージ１０の光学位置を記憶する。さらに、前記自動焦点合わせ検出光学系１００および１３～１９、撮像光学系１１１ならびに像装置１１２を使用して撮像された像をＡ／Ｄ変換装置１１３によって量子化された２次元画像データとして記憶する。ここで、自動焦点合わせ用の窓として位置合わせの後にウエハマーク上になるような窓２０（第２図）を選ぶ。微分絶対

値ヒストグラム演算装置１１４において窓２０内の画像データに対して基準マークと垂直方向（第２図、紙面横方向）に差分絶対値（微分絶対値）を取らせ、微分絶対値画像データを得る。微分絶対値ヒストグラム演算装置１１４においては、この微分絶対値画像データに対して量子化されている微分絶対値濃度を横軸に画素数を頻度とする微分絶対値濃度ヒストグラムが得られる。そこで、微分絶対値濃度最大値方向からゼロ方向に累積分布を取り、前記窓２０内の画素数のr（$r<1$）倍となる画素数に一致する微分絶対値濃度をp点とする。p点より上方の前記ヒストグラムに対して重心gを求め、評価値gとする。重心gは評価値演算装置１１５内において自動焦点合わせ制御装置１１６から送られてくるＸＹＺステージの光学位置zと共に記憶させる。次に、自動焦点合わせ制御装置１１６によってＸＹＺステージ１０を駆動し、ＸＹＺステージ１０を光軸の最初の設定時と逆方向に所定の間隔で変化させる。ＸＹＺ－ステージの位置を自動焦点合わせ制御装置１１６に返す。変化したＸＹＺ－ステージの位置（光学的位置）zに対して前記同様にしてヒストグラムの重心gを求める。評価値演算装置１１５に記憶された前記gと位置zの配列によって、重心gは位置zの関数となり、光学的位置zの変化に対して第６図のような焦点合わせ評価曲線を描く。曲線が左右対象でないのはウエハの位置合わせマークの３次元構造のためである。

位置合わせ方法による非合焦時の特性が予め判っているとしたとき、前記割合rを変化させることによって微細構造（周波数の高い構造）に着目するか、対局的構造（周波数の低い構造）に着目するかを区別できる。

そこで、使用する位置合わせ方法にとって最も適切な光学位置を決定するような割合rを本実施例で使用する自動焦点合わせに従って導くことができる。また、決定されたrに対しては半導体工程間差に依存せず、ほぼ同一の周波数成分をもった画像が得られるような光学位置を決定することができる。

また、算出された評価関数（第６図）の形によって最大値廻りで補間手段を使用して合焦点を求めたり、最大値点以外の停留点を求めたり、または評価関数の微分関数より極小値を求めたりすることで、位置合わせ方法の最適光学的位置を決定することができる。

このようにしてウエハ上の位置５１でのウエハマークの位置合わせに対して最適な光学的位置を検出することができた。

次に、自動焦点合わせ制御装置１１６によってＸＹＺステージ１０を光軸垂直方向（ＸＹ方向）に駆動させて、ウエハ上の適当な別の位置（例えば第５図の５２の位置）に存在する位置合わせマークが撮影されるようにし、上記同様にして位置５２でのウエハマークの位置合わせに対して最適光学位置を検出する。さらに同様の方法によって、第５図における他の位置５３、５４および５５に位置する各々のウエハマークの位置合わせに対して最適光学位置を検出する。位置５１～５５の５箇所のウエハマークの位置合わせに対す

る最適光学位置を検出したことをステップ４０２で判定すると、処理をステップ４０４に移す。

ステップ４０４では、このようにして得られた各ウエハ位置での位置合わせ最適光学位置に対して統計処理（例えば、異常値を除き、平均化する）を行い、ステップ４０５にて得られた値を記憶する。以下、露光時のウエハと装置あるいはウエハとレチクルとの位置合わせにおいては、ＸＹＺ－ステージを記憶された光学位置に駆動させ、そこを位置合わせを行なうための位置合わせ最適光学位置とする。

上述の例においてはウエハ上の各マーク毎に各マークに対する位置合わせ最適光学位置を求めた後に統計処理しウエハ全体の最適光学位置を得た。しかし、ウエハ上の各マーク毎に各マークに対する光学位置に対する評価関数を統計処理しウエハ全体の最適光学位置を得てもよい。

このようにして、焼き付け焦点位置とは別個に位置合わせ用の最適光学位置すなわちベストフォーカス位置を設定した後の両者の差は位置合わせ

と露光時の差としてオフセット量として管理される。通常シーケンスは位置合わせ計測を行った後露光動作に移行する。したがって、位置合わせ時に位置合わせ用の最適光学位置で位置合わせ計測を行われたウエハは、投影レンズの光軸方向の動作に着目すると所定のオフセット量だけ光軸方向に駆動されて焼き付け焦点位置にセットされ、然る後に露光動作が行われる。

本実施例においては、結像系の位置合わせ方法に対する位置合わせ用自動焦点合わせ装置について述べた。しかし、本発明は結像状態を必要としない位置合わせ装置において光軸方向の被露光体の変化によって位置合わせ精度の向上を意図する光学位置検出装置を露光用光学位置検出装置と独立に設置することに一般化できる。その際、光学位置検出装置の光学系は、位置検出装置の光学系と同一のものを使用する。

［発明の効果］

以上のように、本発明によれば、被露光体と装置あるいは被露光体と原版とを位置合わせするに

際し、被露光体の光学位置を、露光時の光学位置とは別途に検出される最適光学位置、例えば半導体製造工程等のみに依存した位置合わせ最適光学位置に設定するようにしたため、位置合わせの精度が向上した。

４．図面の簡単な説明

第１図は、本発明の一実施例に係る縮小投影露光装置の要部概略図、

第２図は、第１図の装置においてウエハマークの位置合わせ時に撮像される像を示す説明図、

第３図は、ウエハの断面図および撮像系の光学的位置と撮像される像との関係を表わした説明図、

第４図は、第１図の装置における位置合わせ用自動焦点合わせ動作の流れ図、

第５図は、本実施例で使用するウエハ上の位置合わせマークの配置図、

第６図は、ウエハマークに対する自動焦点合わせ評価関数の例を示すグラフである。

W：ウエハ
R：レチクル
M：ウエハ上の位置合わせマーク
M'：ウエハ上の位置合わせマーク像
10：XYZ－ステージ
11：投影光学系
12：レチクルステージ
13：ミラー
14：基準マーク
15：基準板
16：対物レンズ
17：ハーフミラー
18：照明光学系
19：ミラー
110：レーザ光源
111：撮像光学系
112：撮像装置
113：A／D変換装置
114：微分絶対値ヒストグラム演算装置

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115：評価値演算装置
116：自動焦点合わせ制御装置
117：露光光用自動焦点合わせ装置
118：露光光用自動焦点合わせ用マーク
119：XYZステージの基準面
20：自動焦点合わせ用窓
30：ウエハ
31：レジスト
32：レジストおよびウエハでの反射光の干渉
33：露光光の焦点位置

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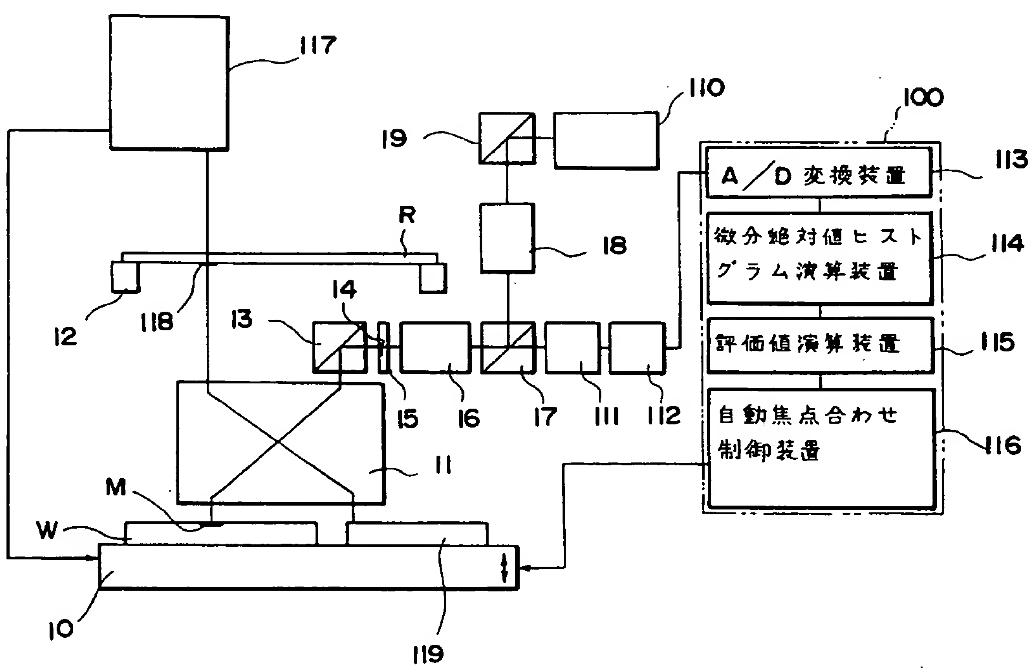
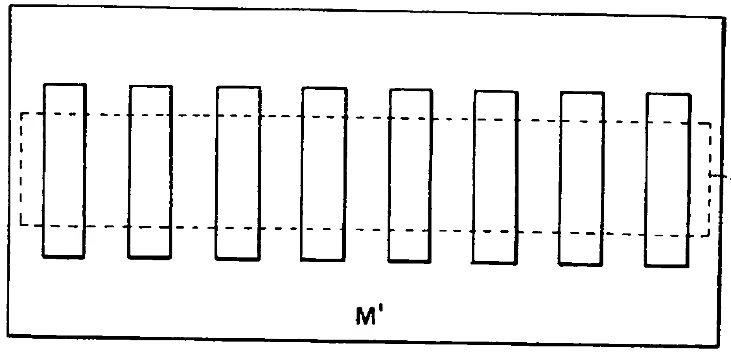
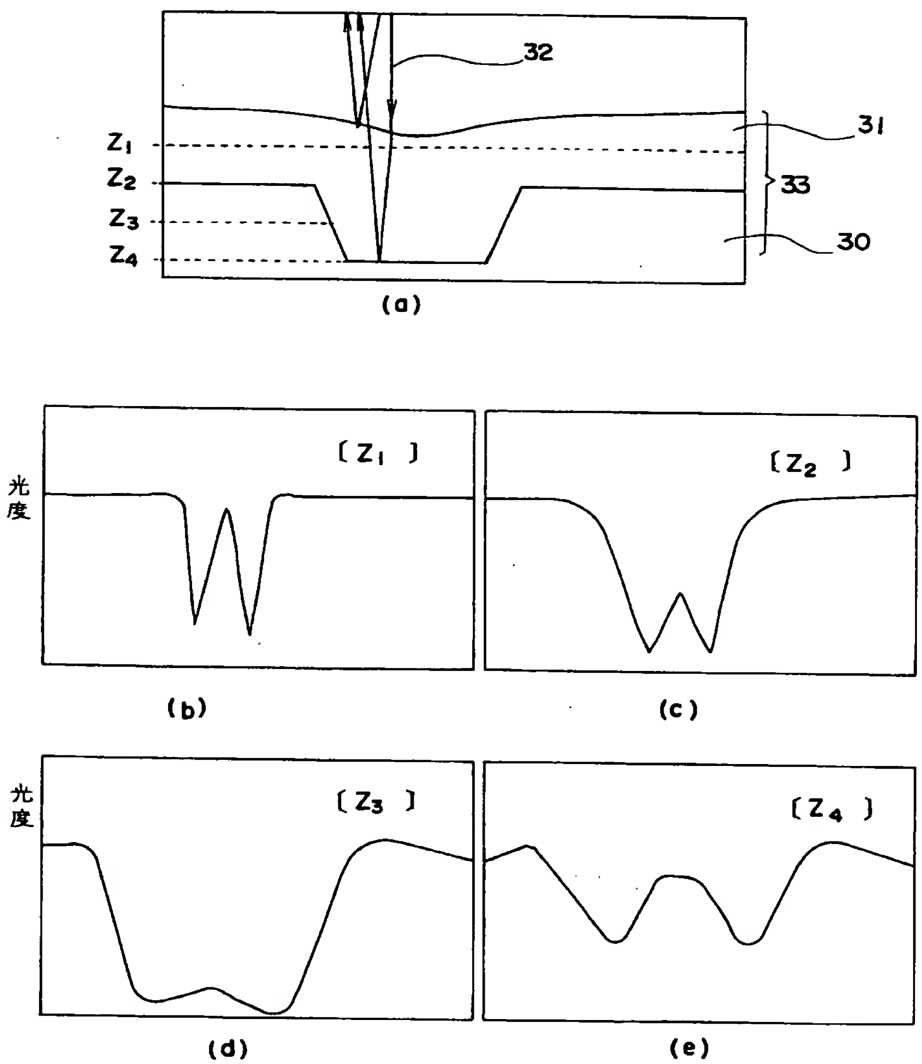


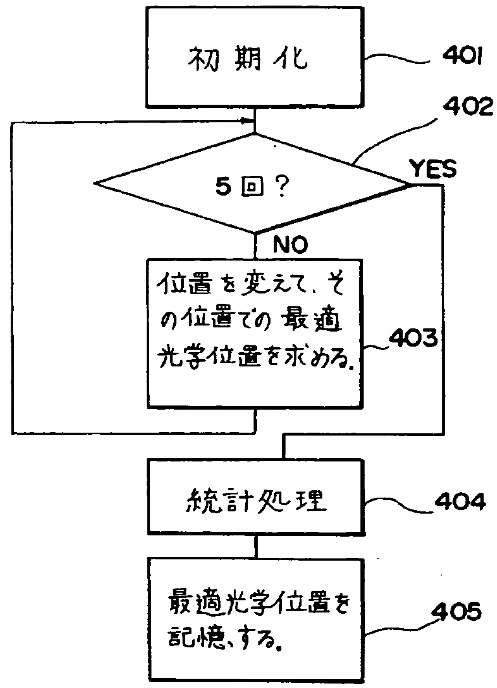
第1図



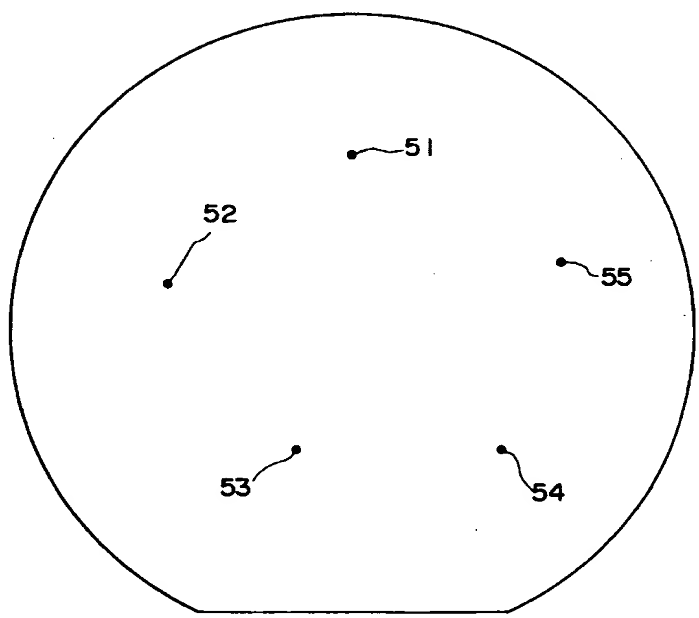
第 2 図



第 3 図


初期化
401
402
5回？
YES
NO
位置を変えて、その位置での最適光学位置を求める。
403
統計処理
404
最適光学位置を記憶する。
405

第 4 図


51
52
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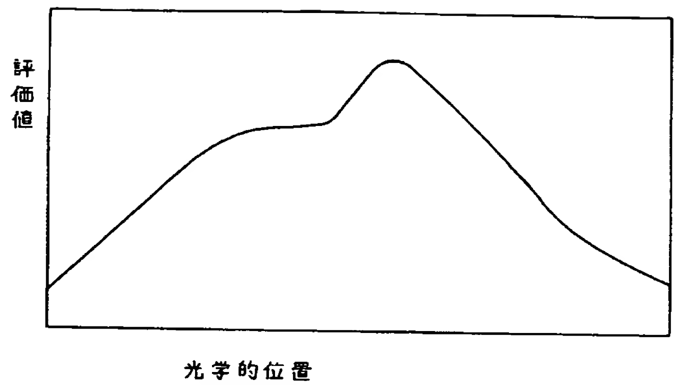
53
54

第 5 図



第 6 図